

WHAT IS CLAIMED IS:

1. A data storage device comprising:
a conductive probe having a tip;
a substrate; and
a data storage medium including a layer of poled ferroelectric material, the ferroelectric layer on the substrate, between the tip and the substrate.
2. The device of claim 1, wherein the ferroelectric material includes a ferroelectric polymer.
3. The device of claim 1, wherein the ferroelectric material includes at least one of PVDF and PTrFE.
4. The device of claim 1, wherein the ferroelectric material includes an inorganic material.
5. The device of claim 1, wherein the probe tip is no more than about 100 nanometers in diameter.
6. The device of claim 1, wherein electrical dipoles in the ferroelectric layer are oriented in a reference direction; the device further comprising a circuit for causing the probe to write to spaced-apart volumes on the ferroelectric layer, dipoles in the spaced apart volumes oriented in the reference direction to store a first logic value, and a different direction to store a second logic value.
7. The device of claim 1, further comprising a protective layer covering the ferroelectric layer, the protective layer not interfering with interactions between the probe tip and the ferroelectric layer.
8. The device of claim 1, further comprising a circuit for causing the conductive probe to apply local electric fields to the ferroelectric layer during write

operations, the local electric fields causing local polarization changes in the ferroelectric material.

9. The device of claim 1, further comprising a circuit for causing the conductive probe to perform block and bulk erasure operations.

10. The device of claim 1, further comprising means for heating the ferroelectric material above its Curie temperature, whereby block and bulk erasure can be performed.

11. The device of claim 1, wherein the substrate includes a semiconductor portion, the semiconductor portion and the ferroelectric layer forming an electrical junction, the device further comprising a read circuit for using the probe to sense changes in capacitance or leakage current of the junction.

12. The device of claim 1, wherein the substrate includes a semiconductor portion, the semiconductor portion and the ferroelectric layer forming an electrical junction, the device further comprising a read circuit for using the probe to apply an ac signal to local areas on the ferroelectric material, and detect changes in a non-linear component of a dielectric constant.

13. The device of claim 1, wherein the substrate includes a semiconductor portion, the semiconductor portion and the ferroelectric layer forming a junction, there being a conductive channel in the vicinity of the junction, width of the conductive channel spanning multiple bits, the device further comprising a circuit for reading the bits, the circuit sensing at least one property of the channel.

14. The device of claim 13, further comprising a second circuit for using the probe to flip bits of the channel while the other circuit reads the bits.

15. The device of claim 14, further comprising a circuit for deducing values of the bits from the at least one sensed property.

16. The device of claim 1, further comprising means for detecting deformation of the probe while the probe is scanned across the ferroelectric layer, the deformation indicating polarization changes in the ferroelectric layer.

17. The device of claim 1, wherein the probe includes a section made of a piezoelectric material, and wherein the circuit causes the probe to apply an electric field to the ferroelectric layer, the means detecting positional changes of the tip as the tip scans the bit, the positional change indicating a polarity reversal.

18. The device of claim 1, further comprising a read circuit for causing the probe to apply a low voltage bias to a bit on the ferroelectric layer, and detecting the leakage current flowing from the ferroelectric layer to the tip, the leakage current indicating polarity reversals in the ferroelectric layer.

19. The device of claim 1, further comprising a read circuit for causing the probe to apply an ac signal and detect capacitance between the tip and ferroelectric layer, the changes in capacitance indicating polarity reversals.

20. The device of claim 1, further comprising a circuit for performing read operations, the circuit
transferring charges from a surface of ferroelectric layer; and
sensing the transferred charges to indicate polarity reversal at scanned bits.

21. A data storage device comprising:
a data storage medium including a layer of poled ferroelectric material;
a plurality of sharp-tip probes;
means for causing the probes to create local polarization changes in the ferroelectric layer during write operations; and
means for using the probes to detect polarization of local areas on the ferroelectric layer during read operations.

22. A method of writing information to a layer of poled ferroelectric material, the method comprising using a probe to create local polarization changes in the material, the probe having a tip diameter no more than several nanometers.

23. The method of claim 22, wherein electrical dipoles in the ferroelectric layer are oriented in a reference direction; wherein the probe is used to write to spaced-apart volumes on the ferroelectric layer, dipoles in the spaced apart volumes oriented in the reference direction to store a first logic value, and a different logic direction to store a second logic value.

24. The method of claim 22, wherein the probe is used to write to spaced apart locations on the ferroelectric layer such that the spaced apart locations have the same electrical dipole alignment as the rest of the ferroelectric layer, whereby information at the spaced apart locations is erased.

25. The method of claim 22, further comprising heating the ferroelectric layer above its Curie temperature, whereby block erasure of the ferroelectric layer is performed.

26. The method of claim 22, further comprising heating selected areas of the ferroelectric layer above the Curie temperature of the ferroelectric layer, whereby the areas of the ferroelectric layer are erased.

27. A method of reading information from a ferroelectric layer, the method comprising:

scanning a surface of the ferroelectric layer with a probe having a sharp tip, the tip having a diameter of several nanometers; and

using the probe to detect polarity reversals at designated locations on the ferroelectric layer, each polarity reversal at a designated location indicating a first stored value at that designated location, each non-reversal of polarity at an expected location indicating a second logic value stored at that designated location.

28. The method of claim 27, wherein the ferroelectric layer is on a semiconductor substrate, the substrate and the ferroelectric layer forming an electrical junction, the probe being used to sense changes in capacitance or leakage current of the junction.

29. The method of claim 27, wherein the ferroelectric layer is on a semiconductor substrate, the substrate and the ferroelectric layer forming an electrical junction, wherein the probe is used to apply an ac signal to local areas on the ferroelectric material, and wherein changes in a non-linear component of a dielectric constant are detected.

30. The method of claim 27, wherein the ferroelectric layer is on a semiconductor substrate, the substrate and the ferroelectric layer forming an electrical junction, there being a conductive channel in the vicinity of the junction, the conductive channel spanning multiple bits, wherein reading the bits includes sensing at least one property of the channel, wherein the probe is used to flip dipoles spanned by the channel.

31. The method of claim 30, further comprising deducing values of the bits from the at least one sensed property.

32. The method of claim 27, wherein deformation of the probe is detected while the probe is scanned across the ferroelectric layer, the deformation indicating polarity reversals in the ferroelectric layer.

33. The method of claim 27, wherein the probe is used to apply a low voltage bias to a bit on the ferroelectric layer, and wherein leakage current flowing from the ferroelectric layer to the tip is detected, the leakage current indicating polarity reversals in the ferroelectric layer.

34. The method of claim 27, wherein the probe is used to apply an ac signal to the ferroelectric layer; and wherein capacitance between the tip and

ferroelectric layer is detected, changes in the capacitance indicating polarity reversals.

35. The method of claim 27, wherein using the tip includes transferring or inducing charges from a surface of ferroelectric layer; wherein the transferred or induced charges are sensed to indicate polarity reversals at scanned bits; and wherein the method further comprises restoring polarity of the scanned bits.

36. A method of fabricating a data storage medium, the method comprising forming a film on a substrate by coating a dissolved ferroelectric polymer on the substrate and heating to remove solvent in the polymer; and the combination of sputtering the polymer from a solid source and applying a Langmuir-Blodgett process repeatedly.

37. The method of claim 36, further comprising polarizing the film.